3483

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

DIRECTION FINDER SET, RADIO

1. OBJECTIVE

The objective of this MTP is to provide general test procedures required to determine the technical performance characteristics of radio direction finder sets.

2. BACKGROUND

The requirement for tactical radio intelligence led to the development of radio direction finders SCR-291 and SCR-502. These radio direction finders operated in the HF range, using crossed-adcock antenna systems and motordriven inductive goniometers to provide automatic visual bearing presentation on a cathode ray tube indicator. Succeeding generations of equipment have stressed greater operating flexibility to permit a wide range of applications such as navigation, surveillance, and search.

Current standards permit mobile, fixed station, and semifixed station direction finding with the larger systems providing separate facilities for direction finding, intercept reception, communications reception, telephone communication and frequency measurement.

In its simplest form, a direction finder set consists of three basic elements, a directional antenna, a radio receiver, and an indicator. The directional antenna provides a means for locating the wave front since the antenna output varies with the orientation of the plane of the antenna relative to the wave front. The radio receiver selects and amplifies the desired signal, and the indicator tells the operator when the plane of the antenna is parallel to the wave front.

3. REQUIRED EQUIPMENT

a. Test range
b. Radar or cinetheodolite tracking instrumentation
c. Surveying equipment
d. Signal generators
e. Test transmitters
f. Field intensity meters
g. Standard gain antennas
h. Frequency counters
i. Tactical vehicles as required
j. Meteorological equipment as required

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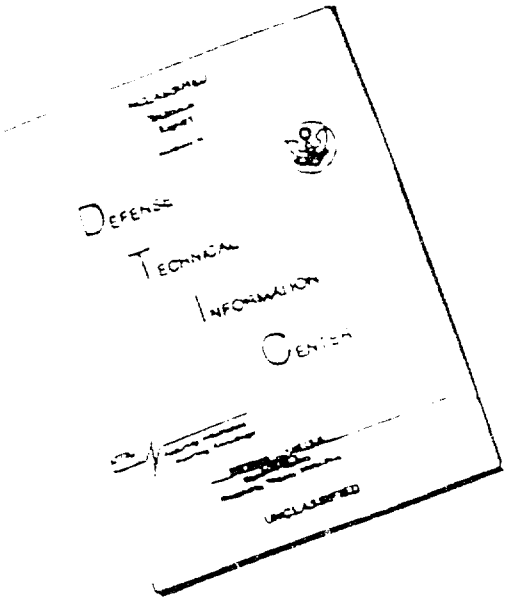

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4. REFERENCES

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B. Jaffe, H.M., The Development of Direction Finder Set AN/TRD-4, Engineering Report - 1149, Signal Corps Engineering Laboratories, 1954.
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E. Smith, W.E., Estimation of Variances for Radio Direction Finding Equipment, University of California, 1962
F. TM 11-487D, Directory of U. S. Army Signal Equipment, Radio Direction Finding Equipment
G. TM-11298, Direction Finder Set AN/TRD-10
H. TM 11-688, Direction Finder Set AN/TRD-4A
I. MTP 6-2-020, Radar Antenna Subsystem Tests
J. MTP 6-2-207, Position Fixing and Navigation Equipment
K. MTP 6-2-242, Receivers-Transmitters, General
L. MTP 6-2-509, Electromagnetic Compatibility Tests
M. MTP 6-2-507, Safety

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

This test procedure describes the tests required to determine and evaluate the technical characteristics and technical performance of:

a. Sensitivity - The objective of this test is to determine the minimum RF field strength required to achieve a standard output indication.

b. Bearing Accuracy - The objective of this test is to determine the ability of the test item to respond cirrectly to an impingent plane wave front. The warm-up time required for a satisfactory bearing indication will be obtained in this subtest.

c. Multiple Bearing Test - The objective of this test is to obtain a measure of overall system performance through analysis of multiple bearing checks.

d. Selectivity - The objective of this test is to determine the test receiver's band pass characteristics.

e. Audio Frequency Response - The objective of this test is to determine the overall audio frequency response of the receiver.

f. Spurious Response - The objective of this test is to determine the response characteristics of the receiver at frequencies other than the tuned frequency.

g. Dynamic Range - The objective of this test is to determine the receiver's behavior between the sensitivity and limiting points.

h. Radar Antennas - The objective of this test is to determine critical performance characteristics of radar antennas.

5.1.2 Common Engineering Tests

Not included in this MTP are the following common engineering tests which apply to this commodity.

a. MTP 6-2-500, Physical Characteristics
b. MTP 6-2-502, Human Factors Engineering
c. MTP 6-2-503, Reliability
d. MTP 6-2-504, Design for Maintainability
e. MTP 6-2-507, Safety

5.2 LIMITATIONS

This test procedure does not attempt to test and evaluate the capabilities of larger direction finding systems to provide intercept reception, spectrum analysis, communication reception, and telephone communications. These subsystems can be tested by referring to other commodity engineering test procedures.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Prior to test assure that the item has successfully completed the requirements of MTP 6-2-507, Safety.

b. Carefully inspect the test item(s) to ensure that no damage has been incurred during transit and that the item(s) is free of manufacturing defects. Record any such damages or deficiencies noted.

c. Assure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

d. Review all instructional material issued with the test item by the manufacturer, contractor, or government as well as reports of previous similar tests conducted on the same type of test items, and familiarize all test personnel with the contents of such documents. These documents shall be kept readily available for reference.

e. If possible, select test equipment having an accuracy of at least ten times that of the function to be measured.

f. Record the following information:

1) Nomenclature, serial number(s), and the manufacturer's name of the test item(s).
2) Last date calibrated of the test equipment selected for the tests and traceability to the National Bureau of Standards.

g. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation.
h. Prepare a sufficient number of samples of all measurements taken to ensure statistical confidence of final data in accordance with MTP 6-1-003, Determination of Sample Size.

6.2 TEST CONDUCT

6.2.1 Sensitivity

a. For test items which employ loop antennas and operate below 20 MHZ the standard electromagnetic field shall be established in a screen room by using a signal generator and terminated transmission line.
b. For test items which operate above 20 MHZ the antenna method shall be used.

NOTE: Whichever method is used for establishing the standard field, caution shall be observed in placing ancillary or test equipment so that they have a negligible effect on the field.

c. Determine the sensitivity as a function of tuned frequency with the antenna oriented for maximum pickup.
d. The output indication shall be as specified in the applicable design requirements.

6.2.2 Bearing Accuracy

a. Establish a calibration range on level terrain and at a sufficient distance from structures and natural obstructions which may cause deviation of a radio signal from a straight line path.
b. The center of the range shall be surveyed and markers established with peripheral markers every 20° in azimuth around the center at a known radial distance.

NOTE: The radial distance shall be such as to ensure a plane wave front at the test items antenna.

c. Emplace the test item at the range center and orient in accordance with the procedures given in the appropriate applications manual.

d. Emplace a CW transmitter at the peripherial markers and perform a bearing readout for each position.

e. Conduct a series of measurements and determine the average time required to obtain a satisfactory bearing readout following application of primary power to the test item (warm-up time).

NOTE: Warm-up time will be minimal when solid state items are used.

f. Determine the field strength at the test item by substituting a field intensity meter for the direction finder set.

g. Repeat the above test as necessary to encompass the particular variable parameters and equipment configurations involved such as:

1) Tuned frequency
2) Impingent field strength (range)
3) Transmission time
4) Antenna type and polarization
5) Antenna mast height
6) Vehicle configuration and orientation
7) Target transmitter velocity (azimuth and elevation)

6.2.2.1 Airborne Emitters

a. The bearing accuracy of airborne emitters shall be determined as a function of emitter height.

b. Bearing readings shall be achieved at least every 20° of azimuth as an aircraft test transmitter orbits the test station at a constant range and altitude.

c. The orbital altitude shall be incrementally increased until an angle of elevation of at least 70° is achieved.

d. The range tracking system shall be employed to track and plot its position for each test condition.

e. The tracking system bearings shall be recorded and used as the azimuth standard.

f. The test items cone of confusion (the vertical cone above the test item in which the bearing readings become ambiguous) shall be determined by mapping of the cone through aircraft flight over the test item and time correlation of bearing readout with radar positioning data.

NOTE: The conical shape may vary as a function of the variables given in paragraph 6.2.2.

6.2.3 Multiple Bearing Test

a. Establish the test item on a test site of known coordinates and orient to true north in accordance with appropriate applications manual.

b. Bearings shall be taken on all stations whose identity can be determined.

c. Operation shall be maintained on an around-the-clock basis to include bearings taken during sunrise and sunset periods and at night when signals are most unstable.

6.2.4 Selectivity

The selectivity test shall be performed in accordance with MTP 6-2-242 Receiver-Transmitter, General, Paragraph 6.2.18

6.2.5 Audio Frequency Response

The audio frequency response test shall be performed in accordance with MTP 6-2-242 Receiver-Transmitter , General, Paragraph 6.2.19

6.2.6 Spurious Response

The spurious response test shall be performed in accordance with MTP 6-2-242 Receiver-Transmitter , General, Paragraph 6.2.20

6.2.7 Dynamic Range

The dynamic range test shall be performed in accordance with MTP 6-2-242 Receiver -Transmitters, General, Paragraph 6.2.21

6.2.8 Radar Antennas

The radar antenna test shall be performed in accordance with MTP 6-2-020 Radar Antenna Subsystem Test.

6.3 TEST DATA

6.3.1 Preparation for Test Data

Data to be recorded prior to testing shall include:

a. Test item nomenclature and serial number
b. Test equipment nomenclature and serial numbers
c. Test equipment calibration date and traceability
d. Test equipment accuracy and stability figures

6.3.2 General

Data to be recorded in addition to specific instructions listed for each individual subtest shall include the following:

a. An engineering log book containing in chronological order, pertinent remarks, block diagrams of test setups, and observations which will augment test data and support engineering evaluation and analysis of the technical performance of the test item.

b. Supporting photographs, calibration records, ground conductivity, topography, meteorological records and recording of test anomolies or deviations from the test plan.

6.3.3 Sensitivity

Sensitivity test data to be recorded shall be as indicated as indicated below:

a. Tuned frequency
b. Field strength required to produce a standard output indication at that frequency.

6.3.4 Bearing Accuracy

Bearing accuracy test data to be recorded shall be as indicated below:

a. Tuned frequency
b. Field strength (range)
c. Transmission time
d. Time of primary power application
e. Time satisfactory bearing readout is achieved within the accuracy tolerance specified for the test item.
f. Antenna type and polarization
g. Antenna height
h. Vehicle configuration and orientation
i. Angle of elevation
j. Rate-of-change of azimuth and elevation angles

6.3.5 Multiple Bearing Test

Multiple bearing test data to be recorded shall be as indicated below:

a. Appropriate entries in the log of DF bearings as outlined in Table I.
b. Local Meteorological data

1) Temperature
2) Humidity
3) Air density

NOTE: Upper-air data provided shall include the height and intensity of all inversions and the refractive index or gradient of the index when conditions deviate from the standard radio atmospheric conditions.

Table I. Data Form For Multiple Bearing Test

Log of DF Bearings

DF Set: _____ Test Site Location: _____

Date: _____ Operator: _____

Weather Conditions: _____

(a) Entry No.	(b) Time	(c) Station Call	(d) Station Location	(e) Station Freq.	(f) Measured Bearing	(g) True Bearing	(h) Signal Strength	(i) Error (g)-(f)	(j) Remarks

6.3.6 Selectivity

Selectivity test data shall be recorded in accordance with MTP 6-2-242.

6.3.7 Audio Frequency Response

Audio frequency response test data shall be recorded in accordance with MTP 6-2-242.

6.3.8 Spurious Response

Spurious response test data shall be recorded in accordance with MTP 6-2-242.

6.3.9 Dynamic Range

Dynamic range test data shall be recorded in accordance with MTP 6-2-242.

6.3.10 Radar Antenna

Radar antenna test data shall be recorded in accordance with MTP 6-2-020.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Sensitivity

Sensitivity test data shall be reduced as necessary in order to present the data in the units specified in the test criteria. In addition to presentation of the tabular test data indicated in paragraph 6.3.3, a graph shall be constructed following the example below:

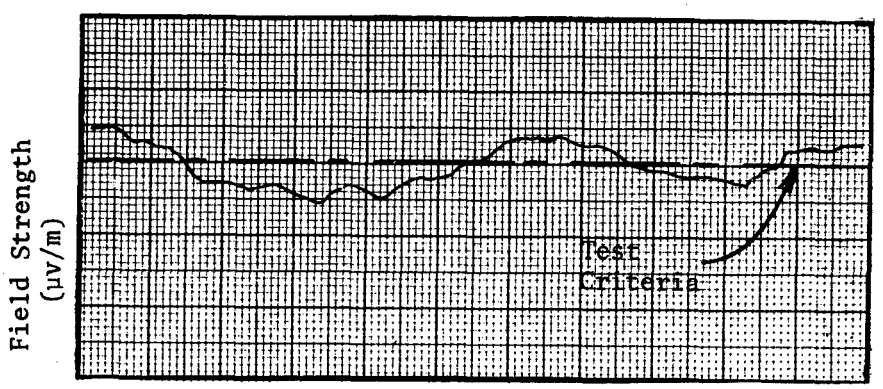

Figure 1. Sensitivity Data Plot

6.4.2 Bearing Accuracy

a. Bearing accuracy test data shall be reduced by statistical methods to determine frequency distribution of errors and measure of central tendency and distribution.

b. Distribution of errors shall be presented graphically as indicated in Figure 2.

c. Bearing accuracy shall be displayed in the form of mean error as a function of each of the parameters delinated in paragraph 6.2.2.

d. Scatter diagrams of raw test data shall be presented as exemplified in Figure 3.

NOTE: Hypothetical plots of final data are illustrated in Figures 4, 5, 6 and 7. Test criteria or test item design specifications shall be superimposed on the graphs in order to facilitate evaluation.

e. Additional graphs shall be constructed as necessary to display bearing accuracy as a function of other parameters or as required to emphasize equipment limitations such as:

1) Minimum range (maximum signal level)
2) Maximum range (minimum signal level)
3) Minimum elevation angle (including low angle reflection limitations)
4) Elevation angle for lock-on
5) Cone of confusion (maximum elevation angle of revolution)
6) Maximum rate-of-change of azimuth and elevation angles

f. Bearing ambiguities or errors caused by site effects or low angle reflections shall be identified and the conditions or features producing these effects analyzed and reported.

g. Minimum on-time transmission test data shall account for overshoot during search and other difficulties encountered in equipment operating dynamics.

h. Warm-up time data shall be presented as the average or mean elapsed time required for the test item to become operational.

6.4.3 Multiple Bearing Test

a. The data form for the multiple bearing test shall be completed and presented as raw test data.

b. Location of stations on which bearings were taken shall be extracted from the Berne frequency listings, the radio frequency record, or similar reference.

c. Great circle bearings from the test site to the stations shall be calculated by standard spherical trigonometric methods.

d. Data reduction shall, as a minimum, include computation and presentation of bearing error distribution as illustrated in Figure 2. Further reduction of data shall be accomplished as dictated by test criteria, or as necessary to provide a base for system evaluation with respect to error as a function of distance, frequency, bearing, time of day, etc.

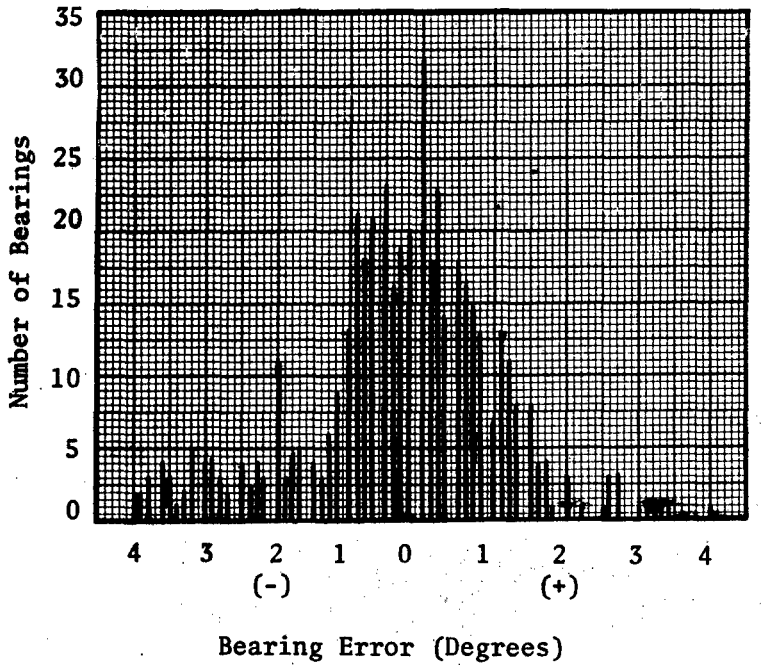

Figure 2. Distribution of Bearing Errors

6.4.4 Selectivity

Selectivity test data shall be reduced and presented in accordance with MTP 6-2-242.

6.4.5 Audio Frequency Response

Audio frequency response test data shall be reduced and presented in accordance with MTP 6-2-242.

6.4.6 Spurious Response

Spurious response test data shall be reduced and presented in accordance with MTP 6-2-242.

6.4.7 Dynamic Range

Dynamic range test data shall be reduced and presented in accordance with MTP 6-2-242.

6.4.8 Radar Antennas

Radar antennas test data shall be reduced and presented in accordance with MTP 6-2-020.

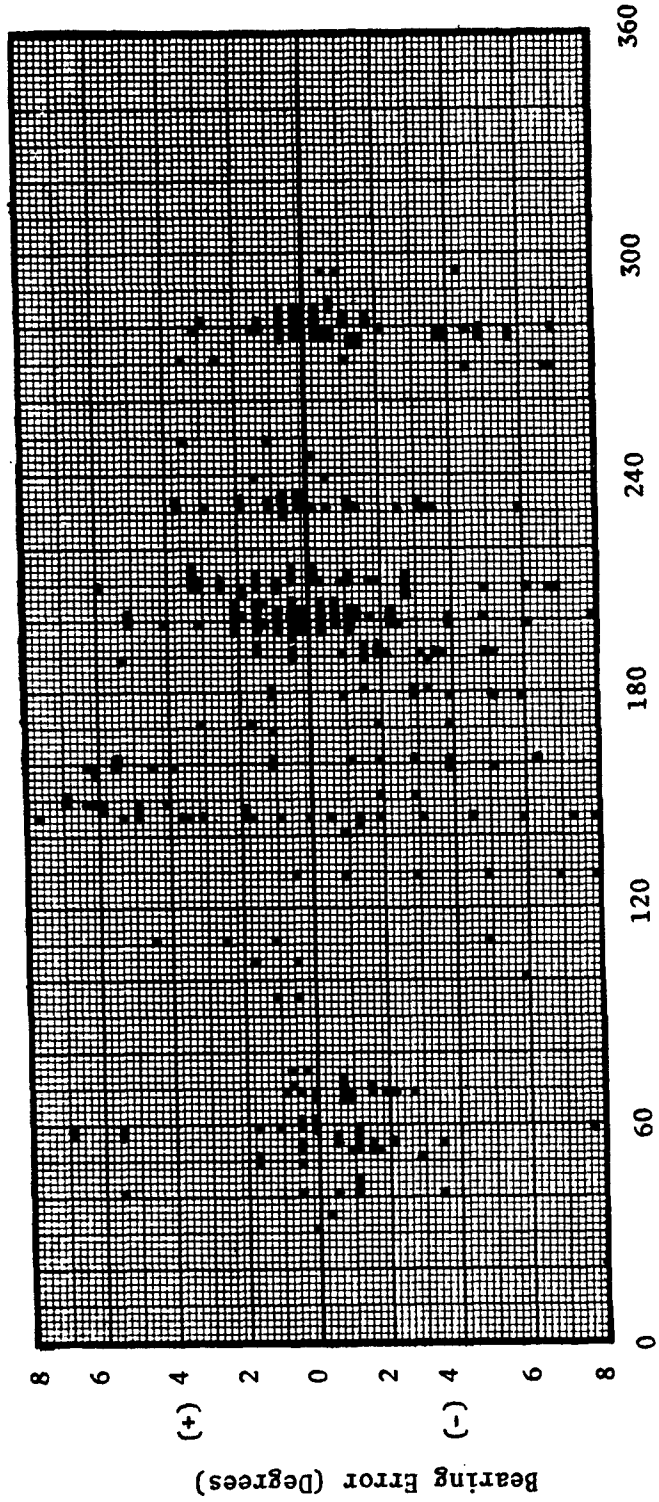

Figure 3. Bearing Error as a Function of Actual Bearing

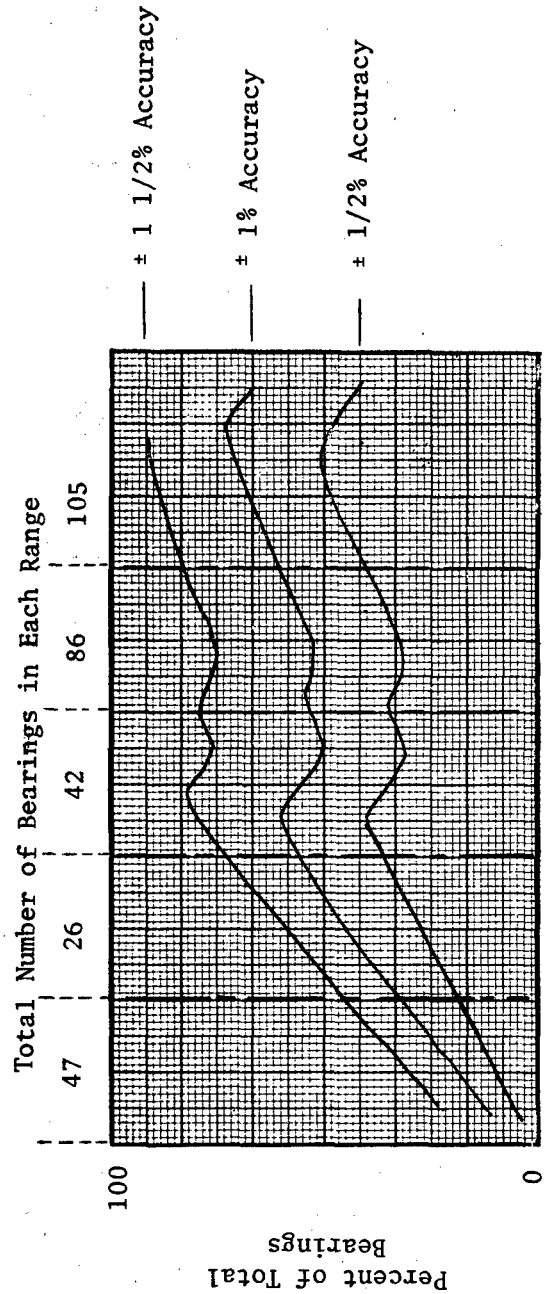

Figure 4. Percent of Total Number of Bearings for a Given Accuracy as a Function of Frequency

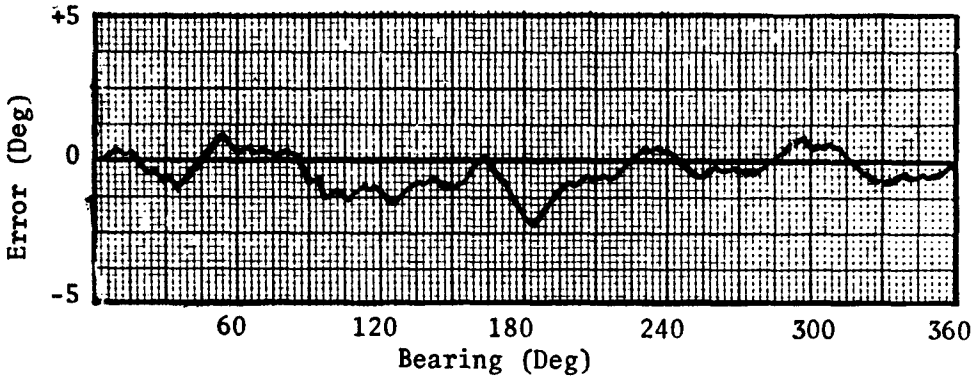

Figure 5. Bearing Accuracy as a Function of Bearing

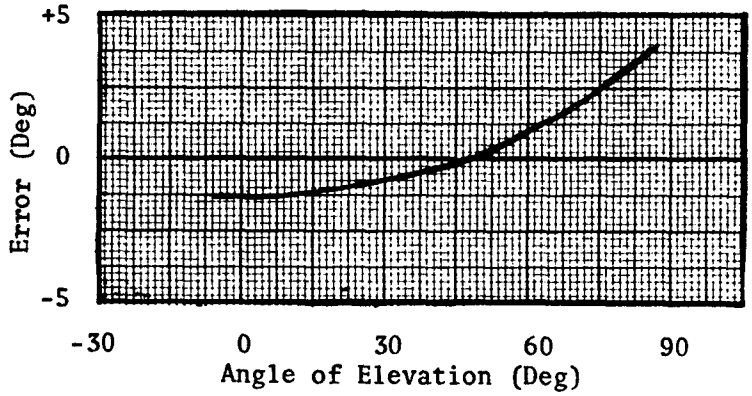

Figure 6. Bearing Accuracy as a Function of Angle of Elevation

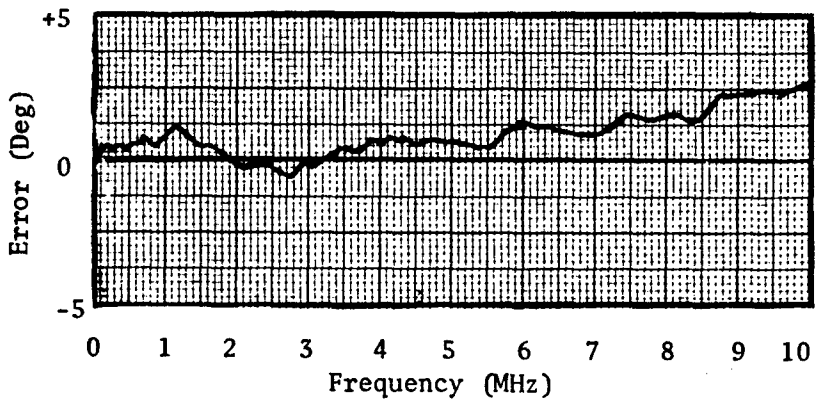

Figure 7. Bearing Accuracy as a Function of Frequency.

APPENDIX A

CONSIDERATIONS IN THE DEVELOPMENT OF A TEST PLAN FOR A SPECIFIC RADIO DIRECTION FINDER SYSTEM

Developmental device systems for location of sources of radio frequency signals will need to satisfy specific later-developed operational requirements in order that highly automated, highly selective and consistently reliable and accurate systems of mission orientation type design can be produced. Requirements for equipment and techniques resembling existing direction finding equipment and techniques might be included in future systems, however, test engineer innovation and research may be required to provide departure from the "classic" concepts of testing presented in this general test procedure. Other commodity test procedures should be consulted and tests extended as necessary to provide a complete engineering evaluation of probable future operational requirements such as:

a. Three or more unit systems capable of simultaneous detection and location with emphasis on obtaining source location rather than obtaining bearings without indication of range.

b. Automatic-search, tracking, and analysis features, complete with programming devices, alarm indicators and other refinements, to perform highly-selective mission-orientation type operation.

c. Means for integrating and correlating data from other units of the system, and timely transfer of usable data to information centers.

d. Control devices to permit an intercepting unit of the system to direct or tune remote units of the location net to the same frequency or other characteristics of the intercepted signal.

GLOSSARY

Ambiguity: Capable of being understood in either of two possible directions.

Azimuth: (See Bearing.)

Bearing: The direction to a distant transmitter measured clockwise from a reference direction such as true north or magnetic north.

Direction: The bearing from the direction finder set to the transmitter.

Direct Bearing: The bearing from the direction finder set to the transmitter.

Error, instrumental: Errors in the bearing, indicated by a direction finder set, which are caused by equipment inaccuracies.

Error, polarization: Errors in the bearing indicated by a direction finder set, introduced by horizontally polarized components of the electrical field under certain transmission conditions. Originally called night effects because errors are generally greatest at night.

Error, site: Errors caused by irregularities of, and obstacles or reflectors on, the terrain around a direction finder set.

Great-circle Path: The shortest distance between two points, measured on the surface of a globe.

Sense Indication or Pattern: An aural indication or visual pattern which can be interpreted to distinguish between direct and reciprocal bearings.

Sense Signal: A radio signal added to the output of a bidirectional antenna to distinguish between direct and reciprocal bearings.

Sensing: The procedure that uses the sense finder portion of a direction finder set to distinguish between direct and reciprocal bearings.